ASSESSING THE EFFECT OF SCALE, DESIGN, AND INDICATORS IN WATERSHED ASSESSMENTS

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CABB

Assessing the Effect of Scale, Design, and Indicators in Watershed Assessments

- Used existing Ohio data to do a "retrospective" assessment
- Database consists of over 10,000 potential stations
- Fish, macroinvertebrate, water chemistry, habitat (QHEI)

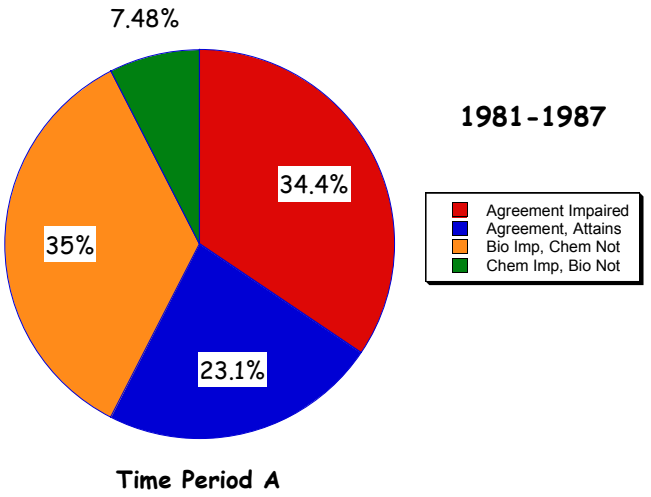
Retrospective Analyses

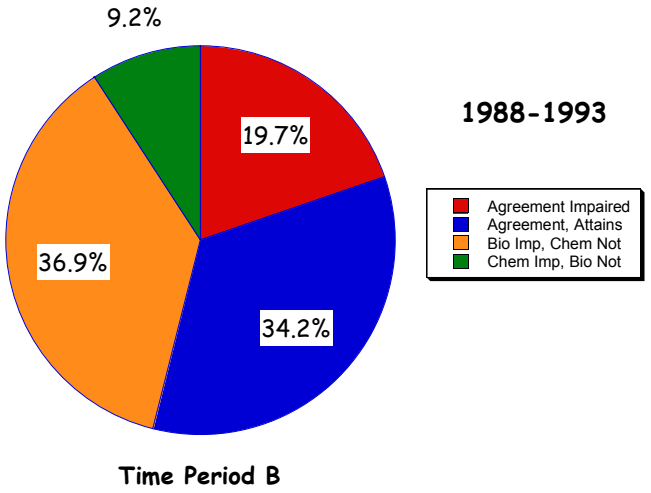
- Indicators:
  - Chemical vs. Biological Indicators
  - Fish vs. Macroinvertebrates
  - Tiered Aquatic Life Uses vs. Single Aquatic Life Uses
- Design
  - Random (REMAP) vs. Intensive Surveys
  - Geometric
    - Attainment Status Estimate vs. Sites Sampled
    - Causes of Impairment Estimates vs. Sites Sampled

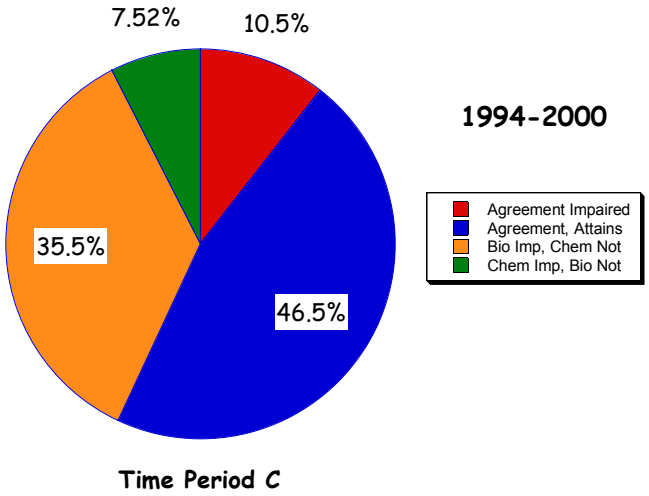
Chemical vs. Biological Measure of Aquatic Life Use Status

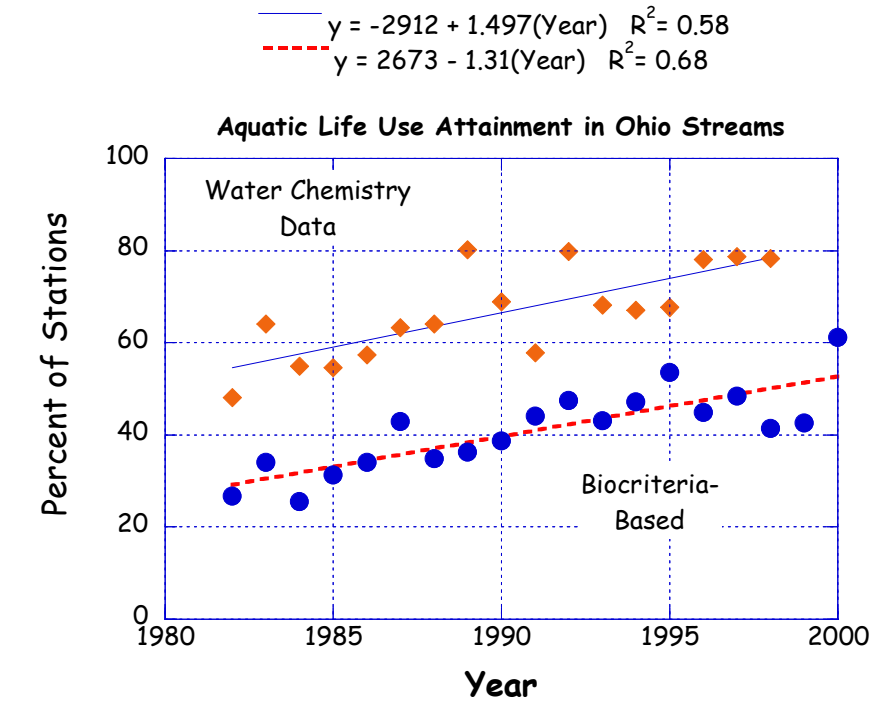
- Biological data – fish/macroinvertebrate data based on tiered aquatic life uses in Ohio
- Water chemistry indicators – Conventional pollutants (D.O., pH, etc) and toxicants such as ammonia, metals, etc.,)

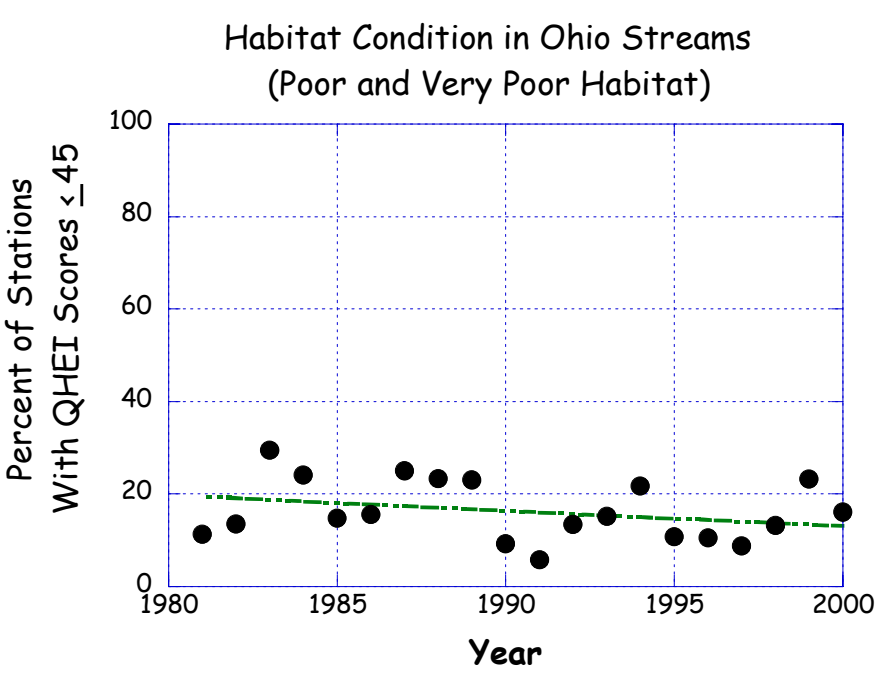
Chemical vs. Biological Indicators of Aquatic Life Use Attainment







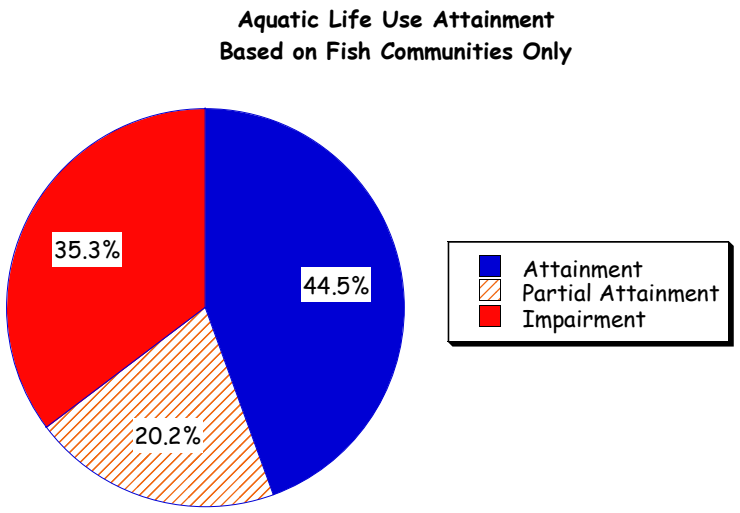

y = -2912 + 1.497(Year) R2= 0.58
y = 2673 - 1.31(Year) R2= 0.68
Aquatic Life Use Attainment in Ohio Streams
Water Chemistry Data
Biocriteria-Based
Percent of Stations
Year
0
20
40
60
80
100
1980
1985
1990
1995
2000

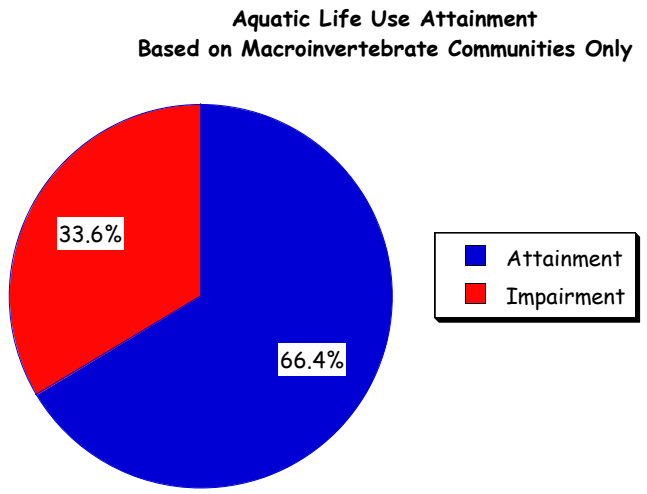

y = 678 - 0.33(Year) R2= 0.10
Habitat Condition in Ohio Streams
(Poor and Very Poor Habitat)
Percent of Stations
With QHEI Scores <_45
Year
0
20
40
60
80
100
1980
1985
1990
1995
2000

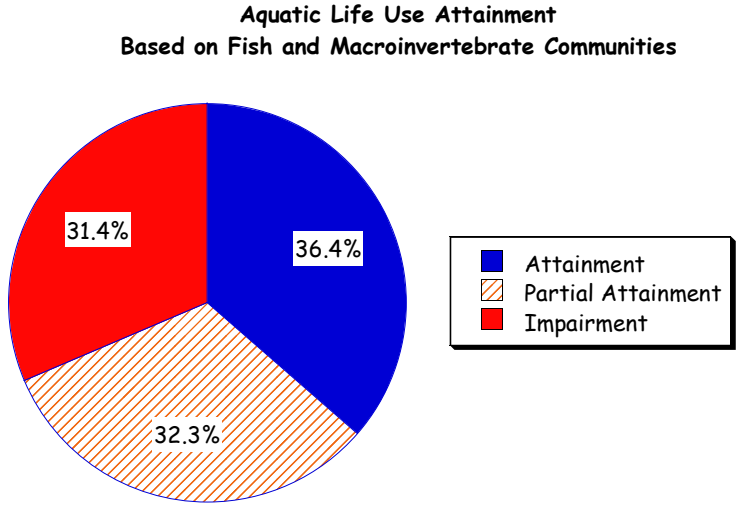
Fish vs. Macroinvertebrates

- Many stations in the Ohio database have both fish and macroinvertebrate data
- What would be the consequence of using a single organism group?

Aquatic Life Use Attainment: Fish vs. Macros



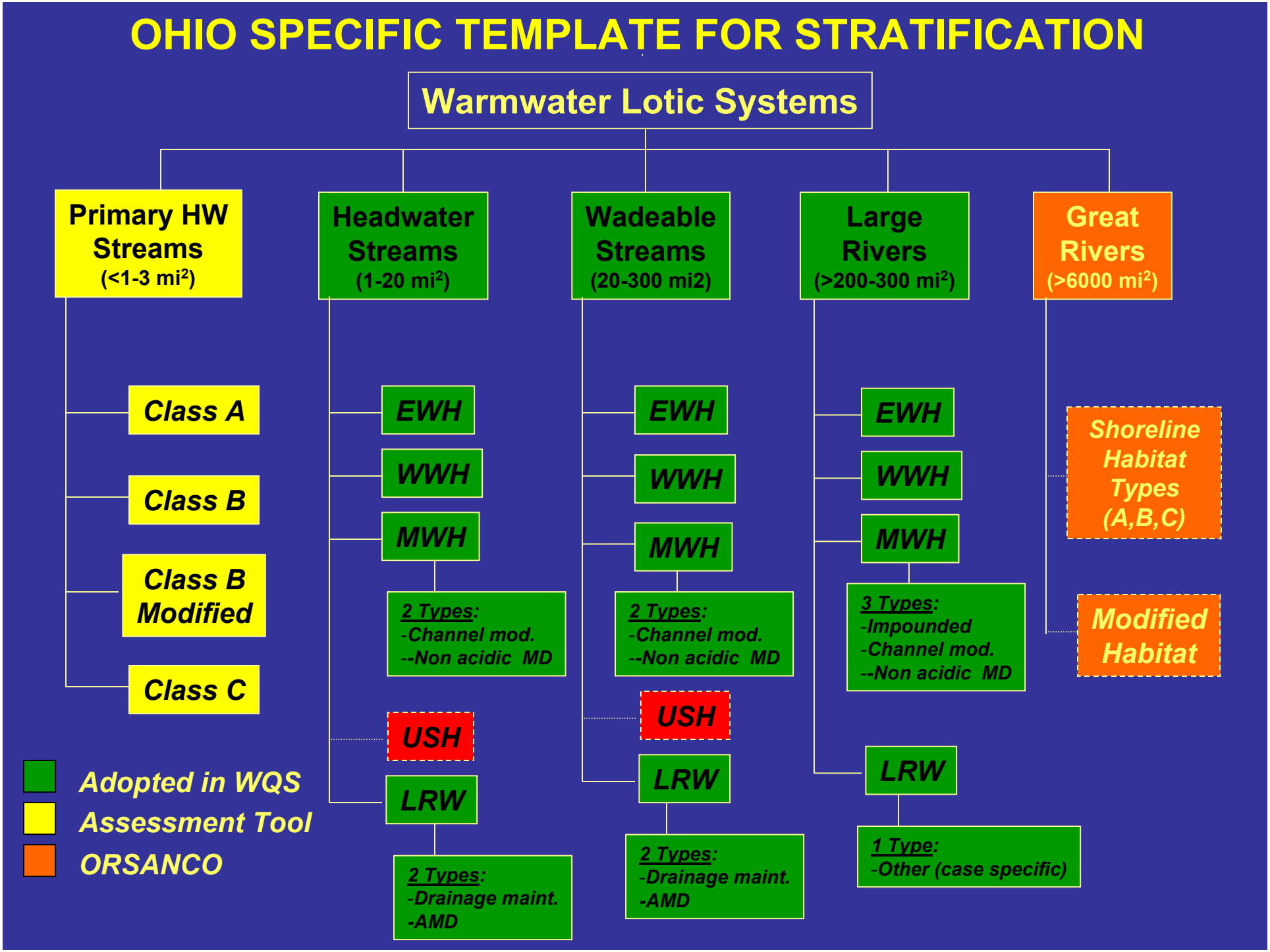




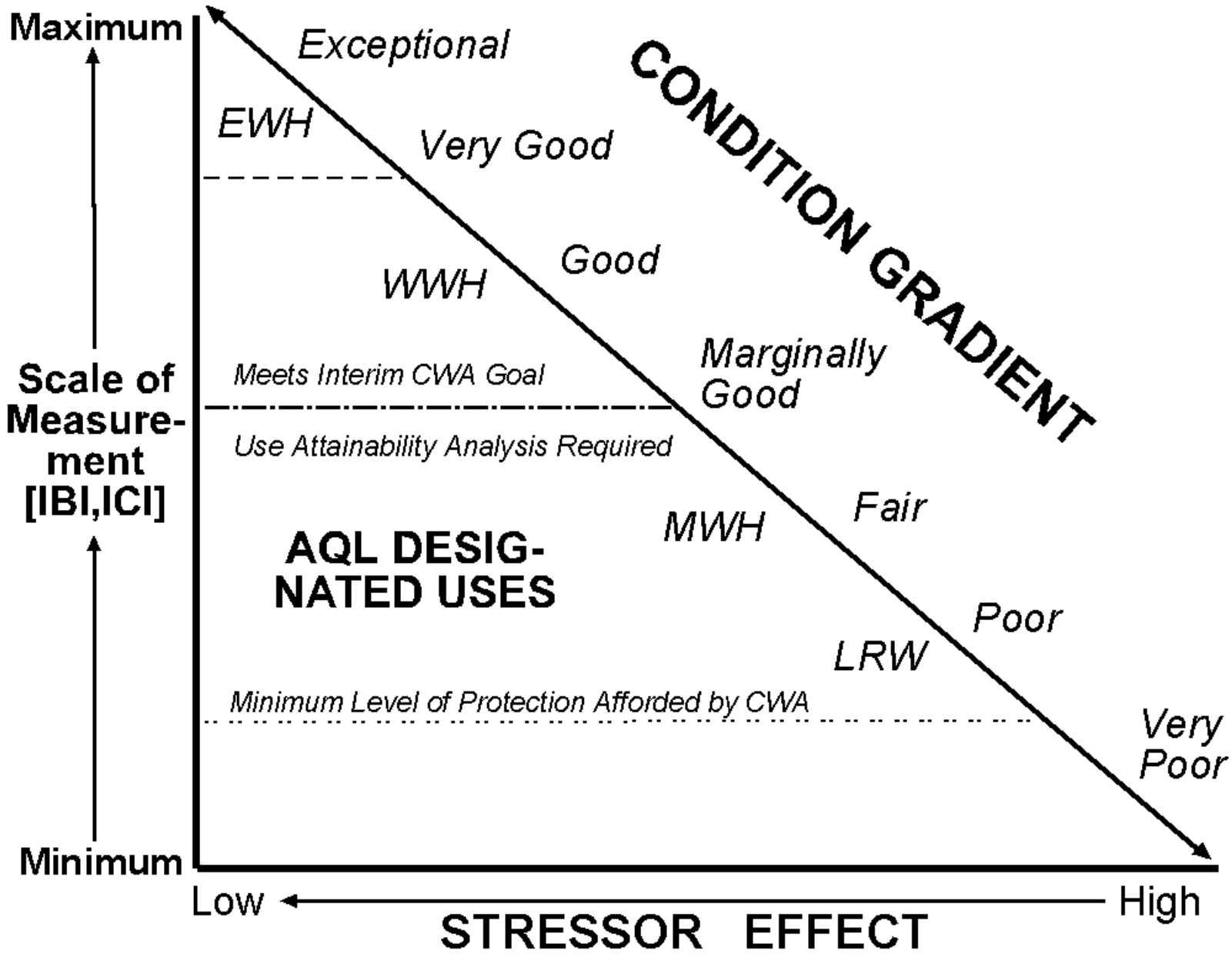
Tiered Aquatic Life Uses vs. Single Aquatic Life Uses

- Ohio has gradually developed a tiered aquatic life use system from the late 1970s to the early 1990s
- Biological expectations change largely along a anthropogenic physical gradient
- Four primary uses in the tiers: Exceptional Warmwater Habitat (EWH), Warmwater Habitat (WWH), Modified Warmwater Habitat (MWH) and Limited Resource Water (LRW)
- Biological data is ultimate arbiter of use, QHEI and habitat data are important sources of information

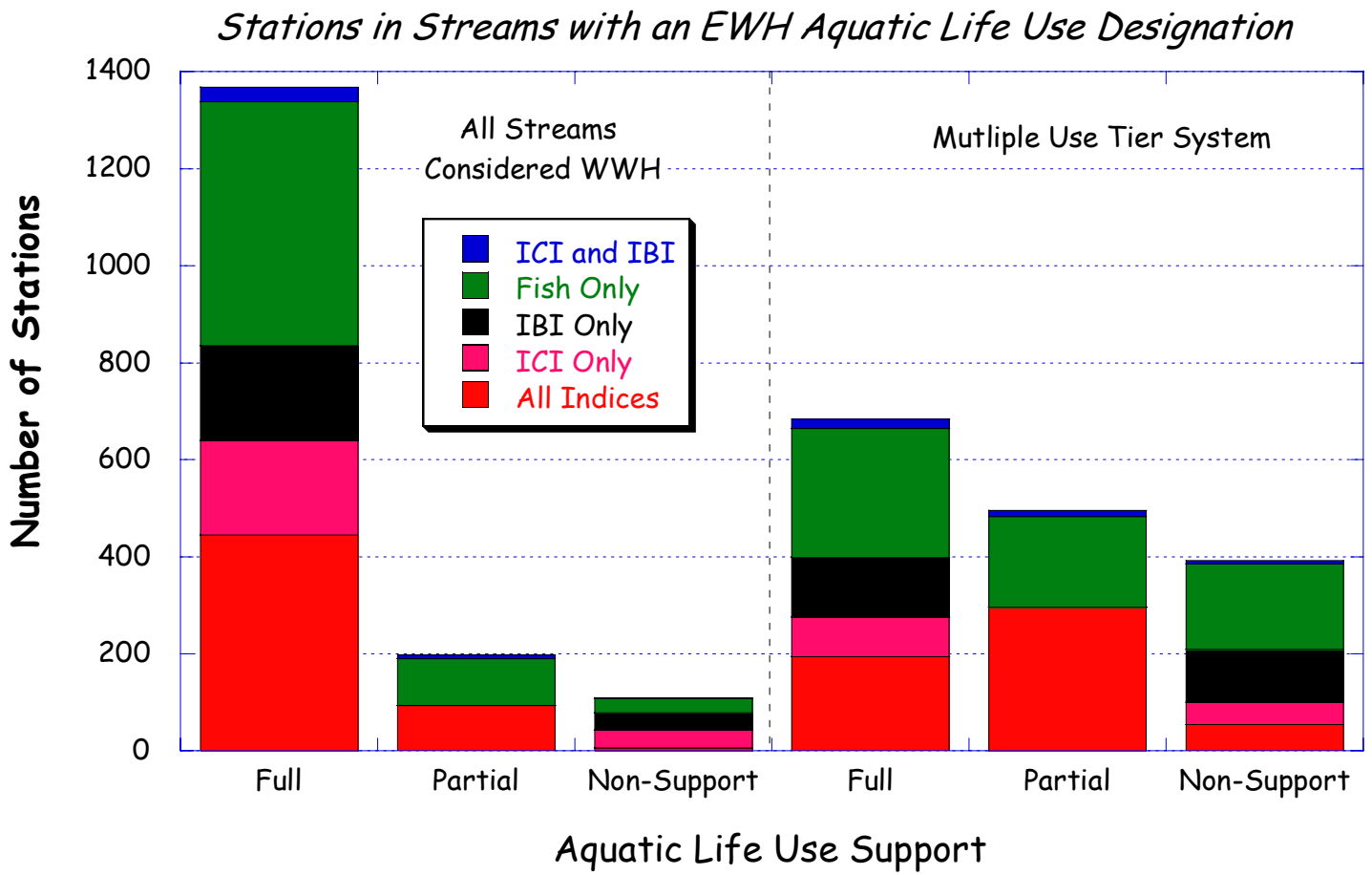
OHIO SPECIFIC TEMPLATE FOR STRATIFICATION



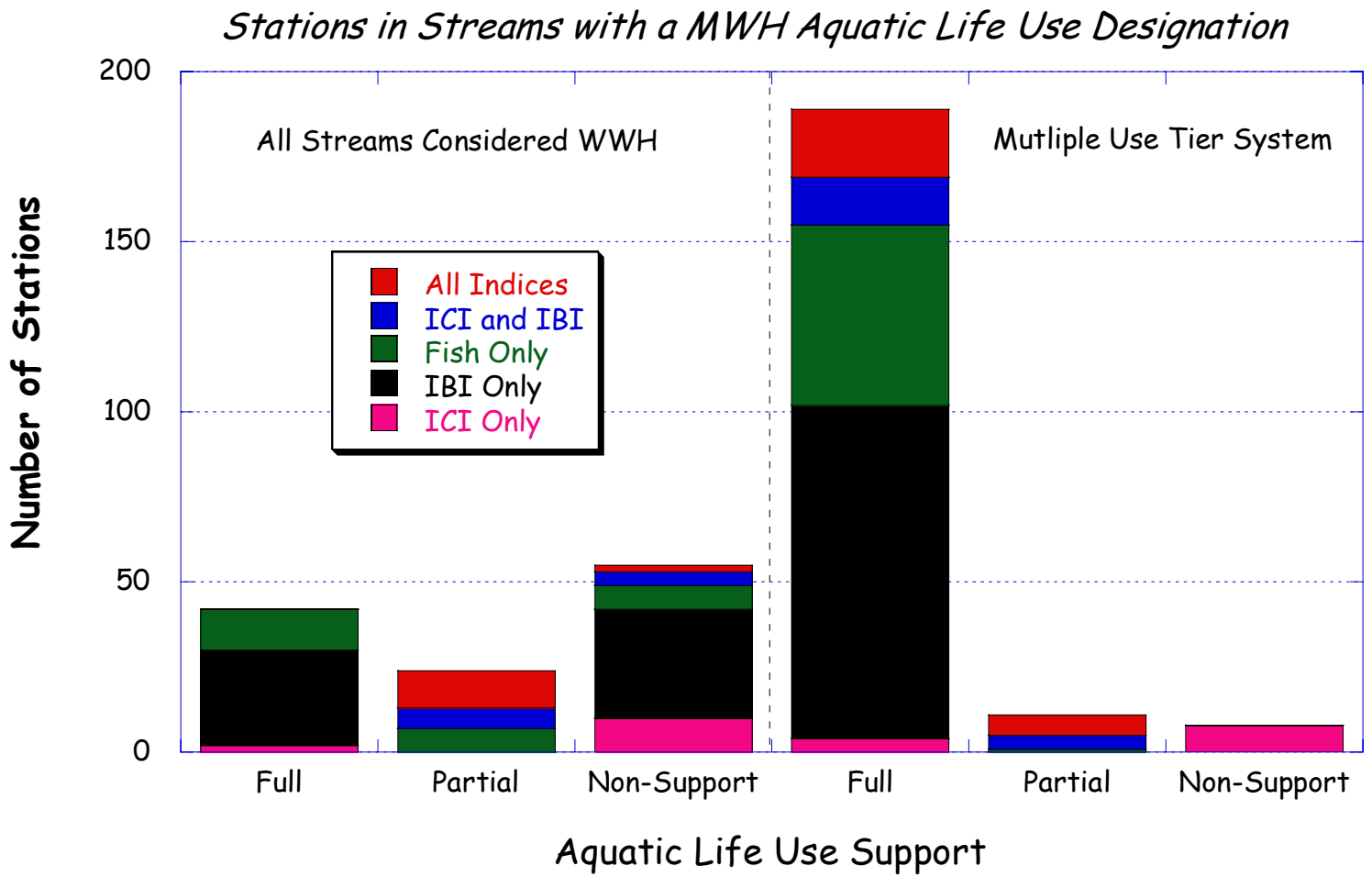
DESIGNATED USE OPTIONS ALONG THE BIOAXIS AND BIOLOGICAL CONDITION GRADIENT



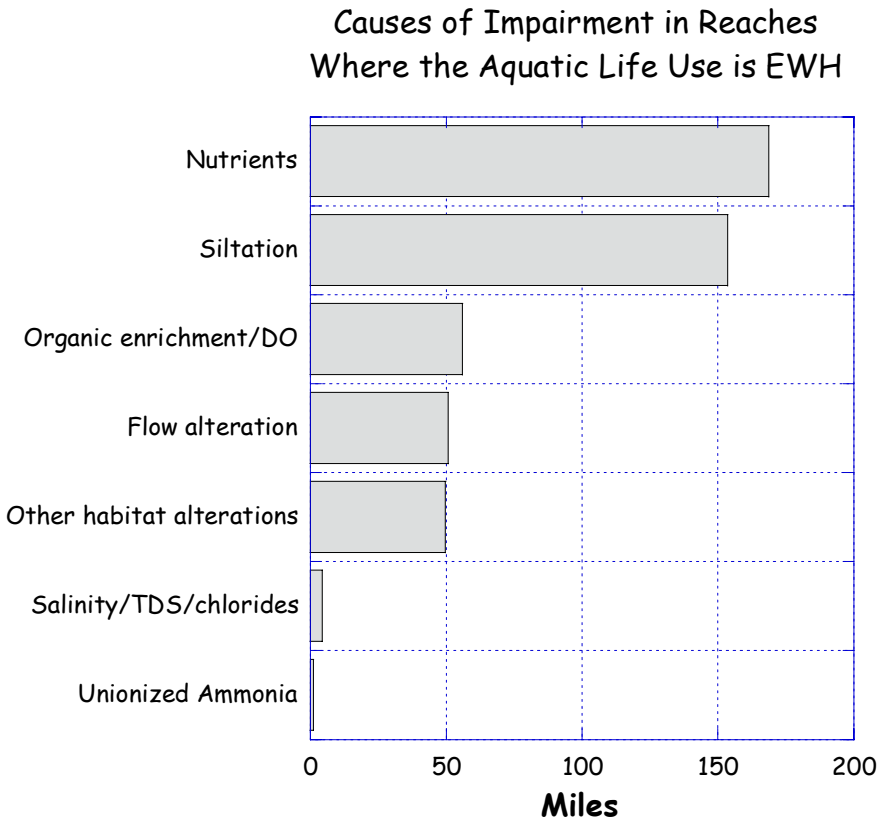
EWH Streams

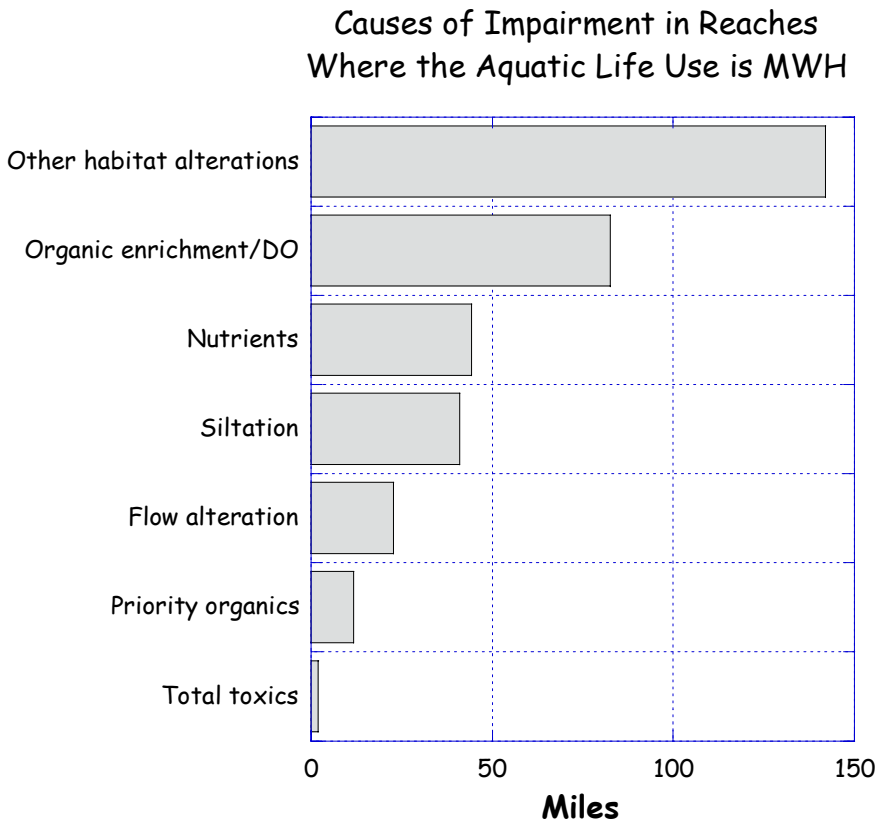

Stations in Streams with an EWH Aquatic Life Use Designation
Number of Stations
1400
1200
1000
800
600
400
200
0
All Streams
Considered WWH
Mutliple Use Tier System
ICI and IBI
Fish Only
IBI Only
ICI Only
All Indices
Full
Partial
Non-Support
Full
Partial
Non-Support
Aquatic Life Use Support

MWH Streams

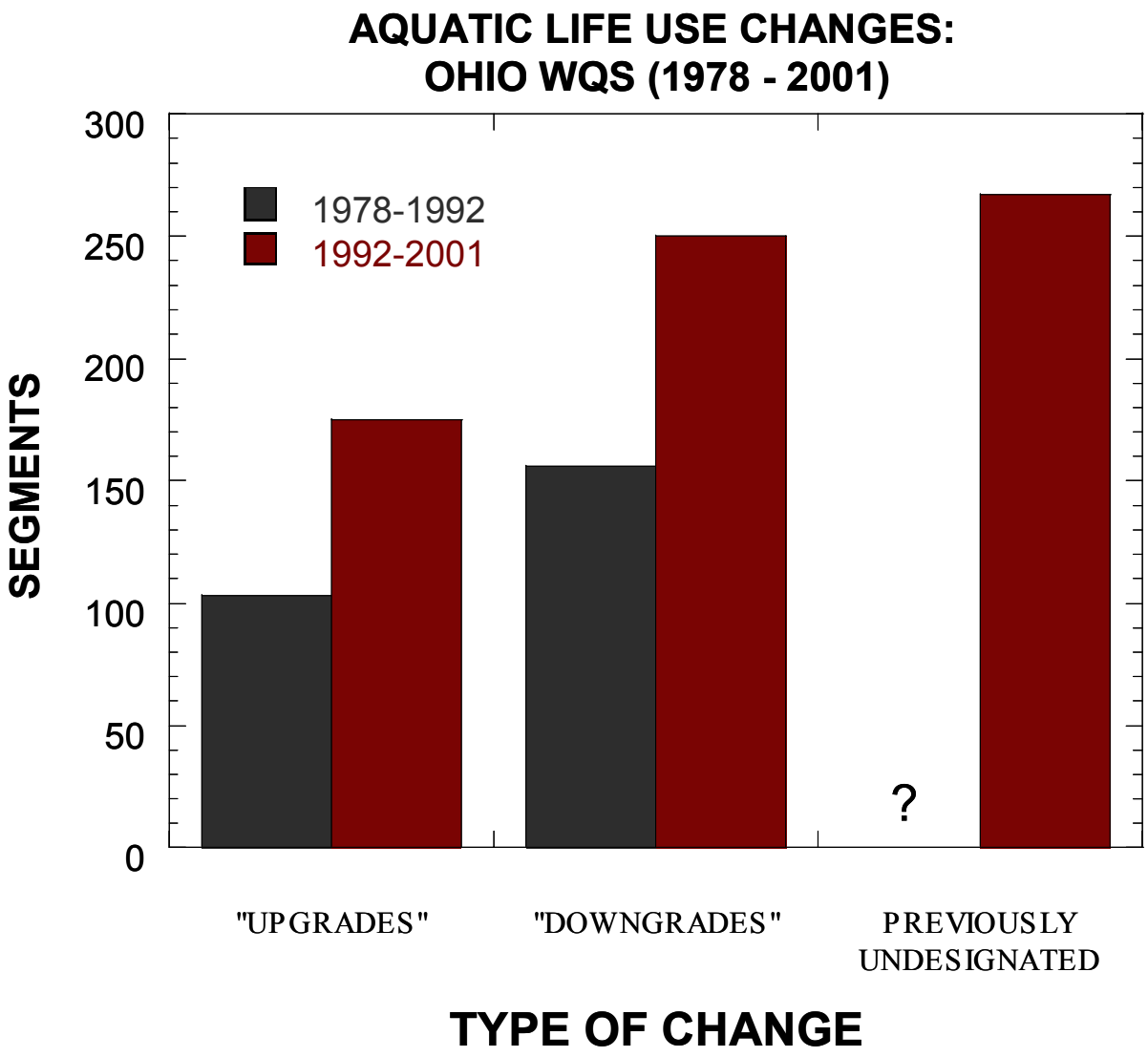

Stations in Streams with a MWH Aquatic Life Use Designation
Number of Stations
200
150
100
50
0
All Streams Considered WWH
Mutliple Use Tier System
All Indices
ICI and IBI
Fish Only
IBI Only
ICI Only
Full
Partial
Non-Support
Full
Partial
Non-Support
Aquatic Life Use Support

Causes of Impairment: EWH vs. MWH

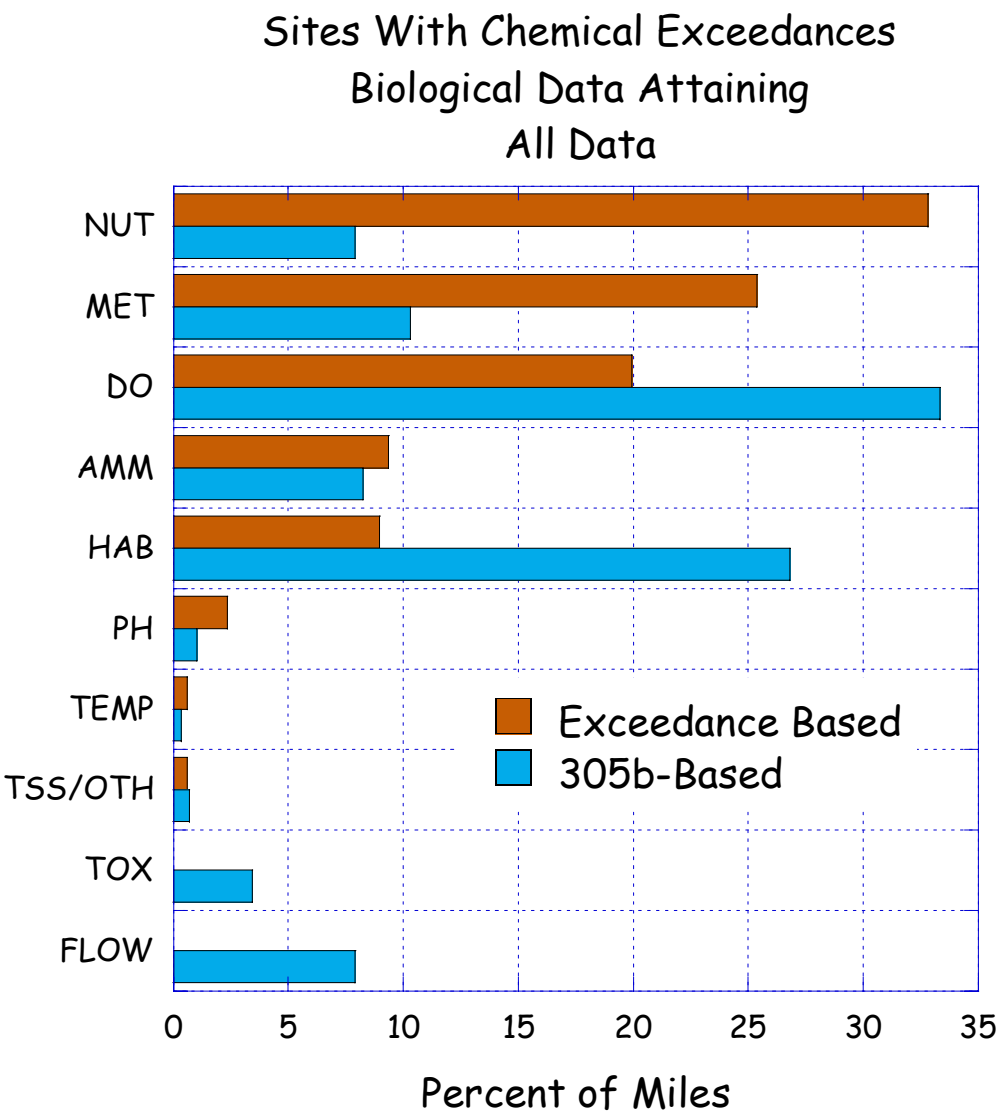




Use Attainability Analyses



Causes of Impairment

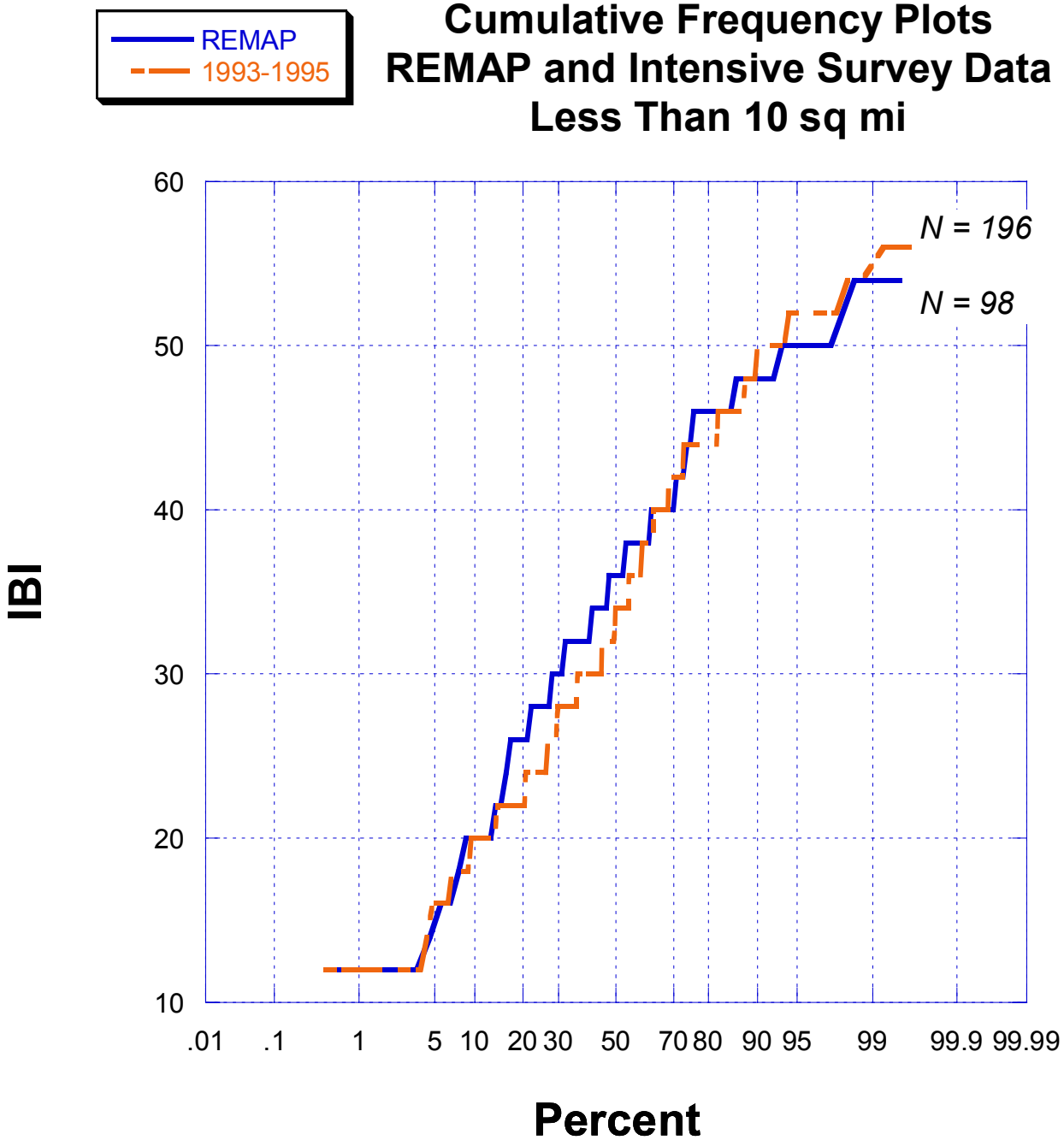


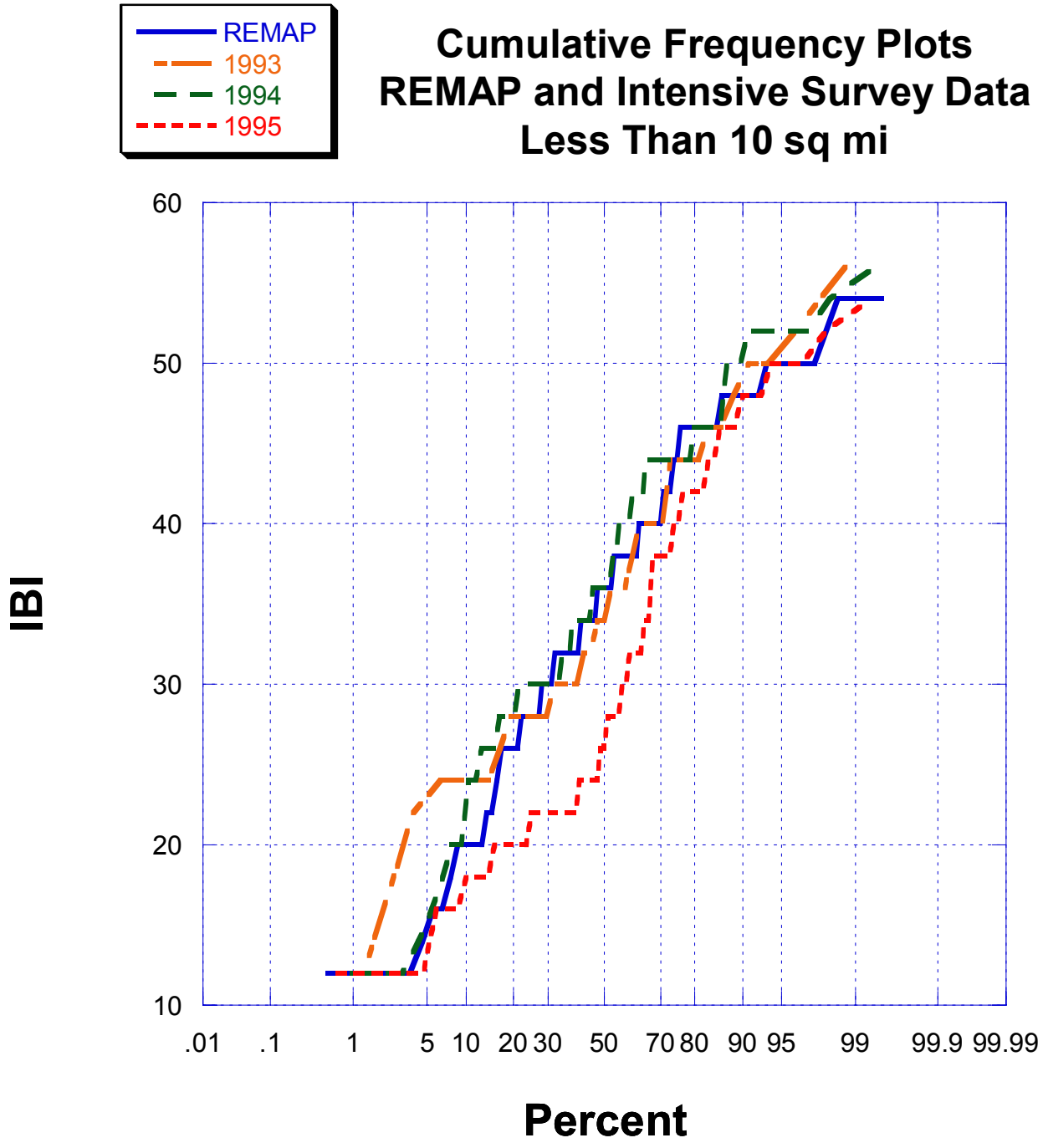
Study Design Issues

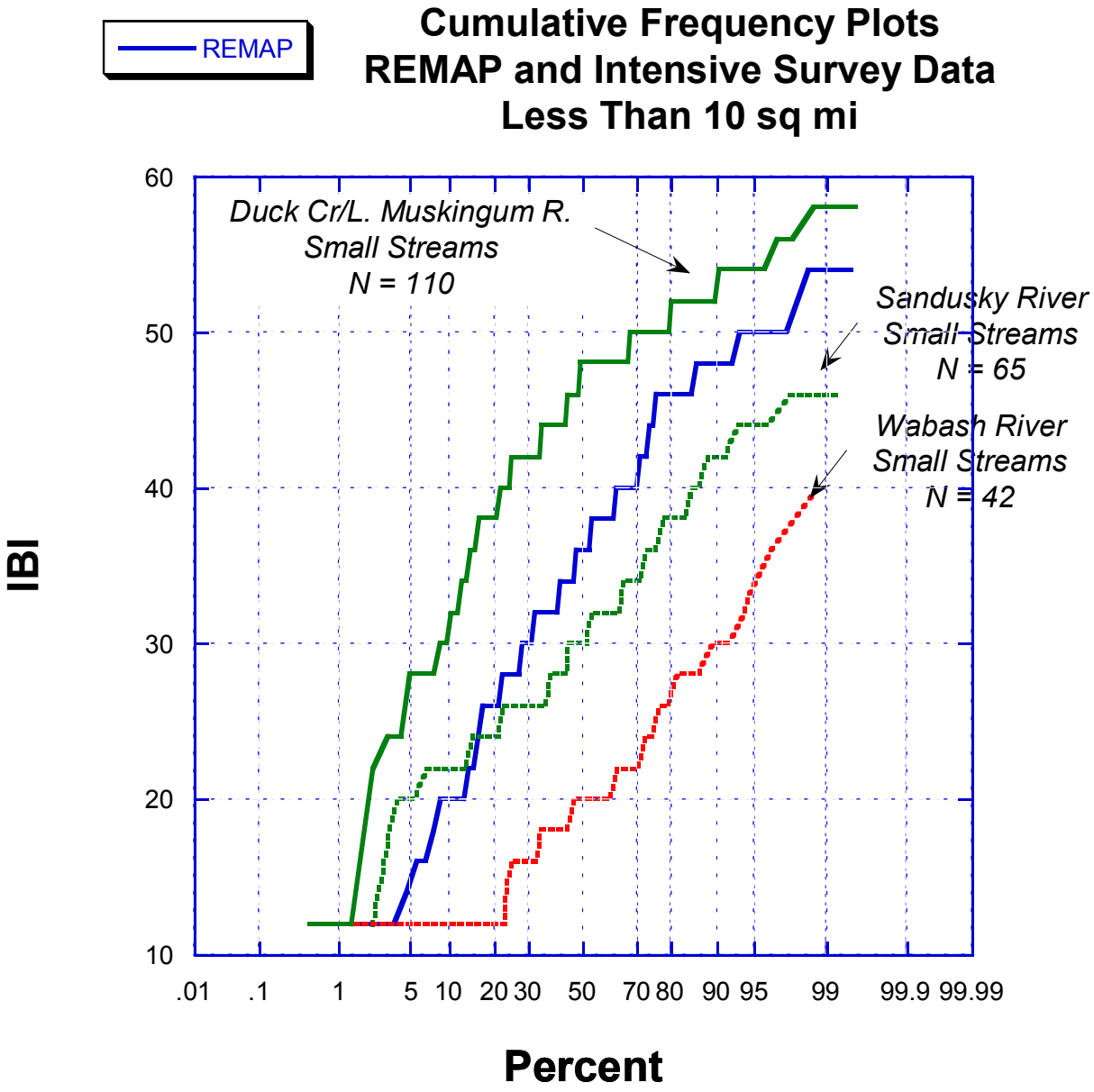
- Data from early-mid 1990s – Regional EMAP, ECBP ecoregion vs. targeted watersheds
- Late 1990s to present, "geometric" site design in watersheds surveys

Intensive Survey Studies by Watershed vs. EMAP Design

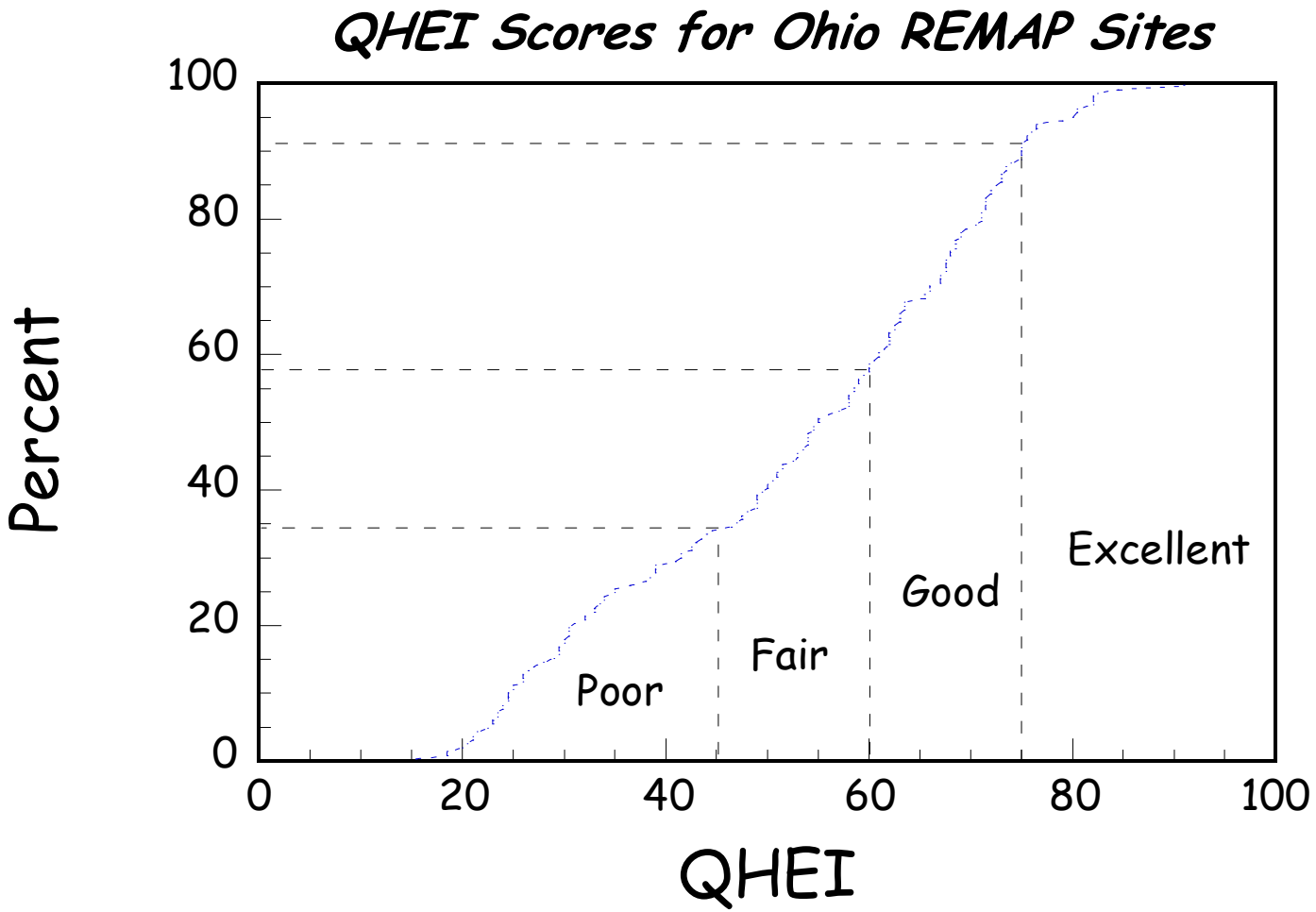
- Compared the results of a REMAP study in the ECBP ecoregion with similar sized streams during watershed surveys (targeted sampling, watershed coverage)
- Are the estimates of attainment accumulated from watershed surveys similar to that from random sample?


REMAP
1993-1995
Cumulative Frequency Plots
REMAP and Intensive Survey Data
Less Than 10 sq mi
IBI
60
50
40
30
20
10
N = 196
N = 98
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent

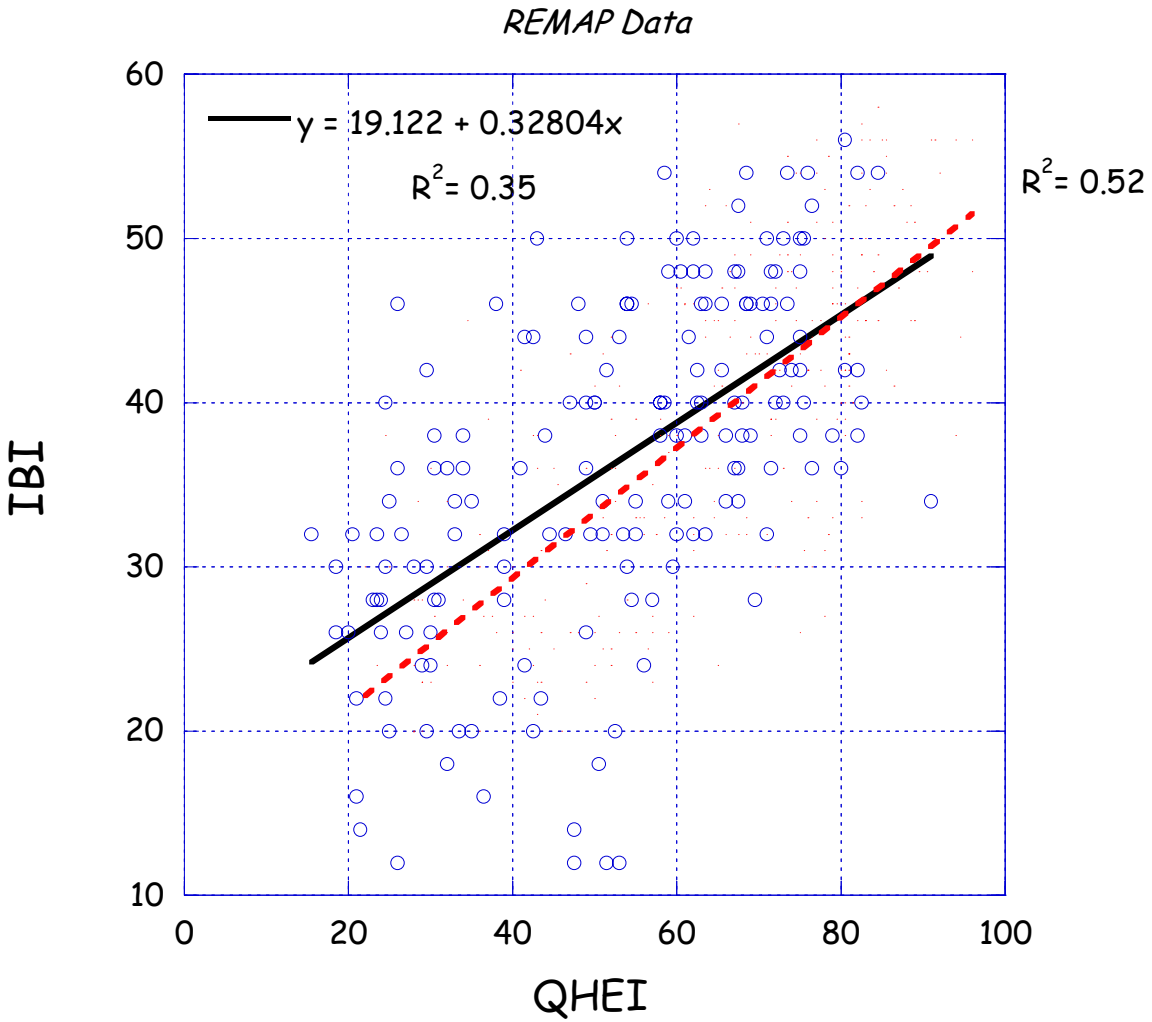

REMAP
1993
1994
1995
Cumulative Frequency Plots
REMAP and Intensive Survey Data
Less Than 10 sq mi
IBI
60
50
40
30
20
10
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent


REMAP
Cumulative Frequency Plots
REMAP and Intensive Survey Data
Less Than 10 sq mi
Duck Cr/L. Muskingum R.
Small Streams
N = 110
Sandusky River
Small Streams
N = 65
Wabash River
Small Streams
N = 42
IBI
60
50
40
30
20
10
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent

Habitat Quality at REMAP Sites

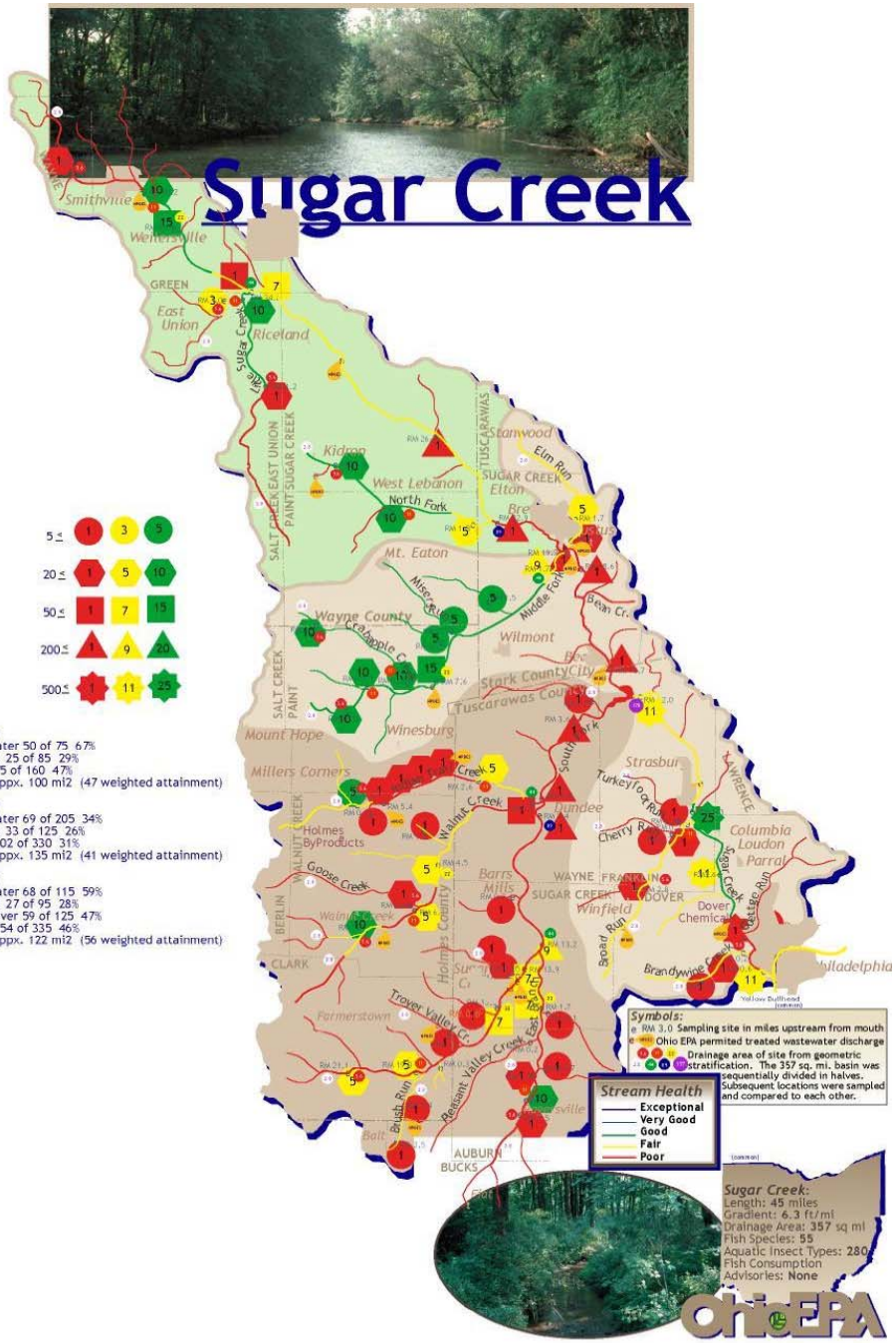


Remap QHEI vs. IBI with Reference Site Overlay



How Many Stations to Get a Stable Estimate of Attainment Status?

- Geometric site design results in sites at mouth of watershed and then at ½ drainage size, ½ again, etc until streams of desired size covered
- In larger streams sites added to gain longitudinal profile related to sources, tribs, etc.
- Result is census like design with even geographic coverage



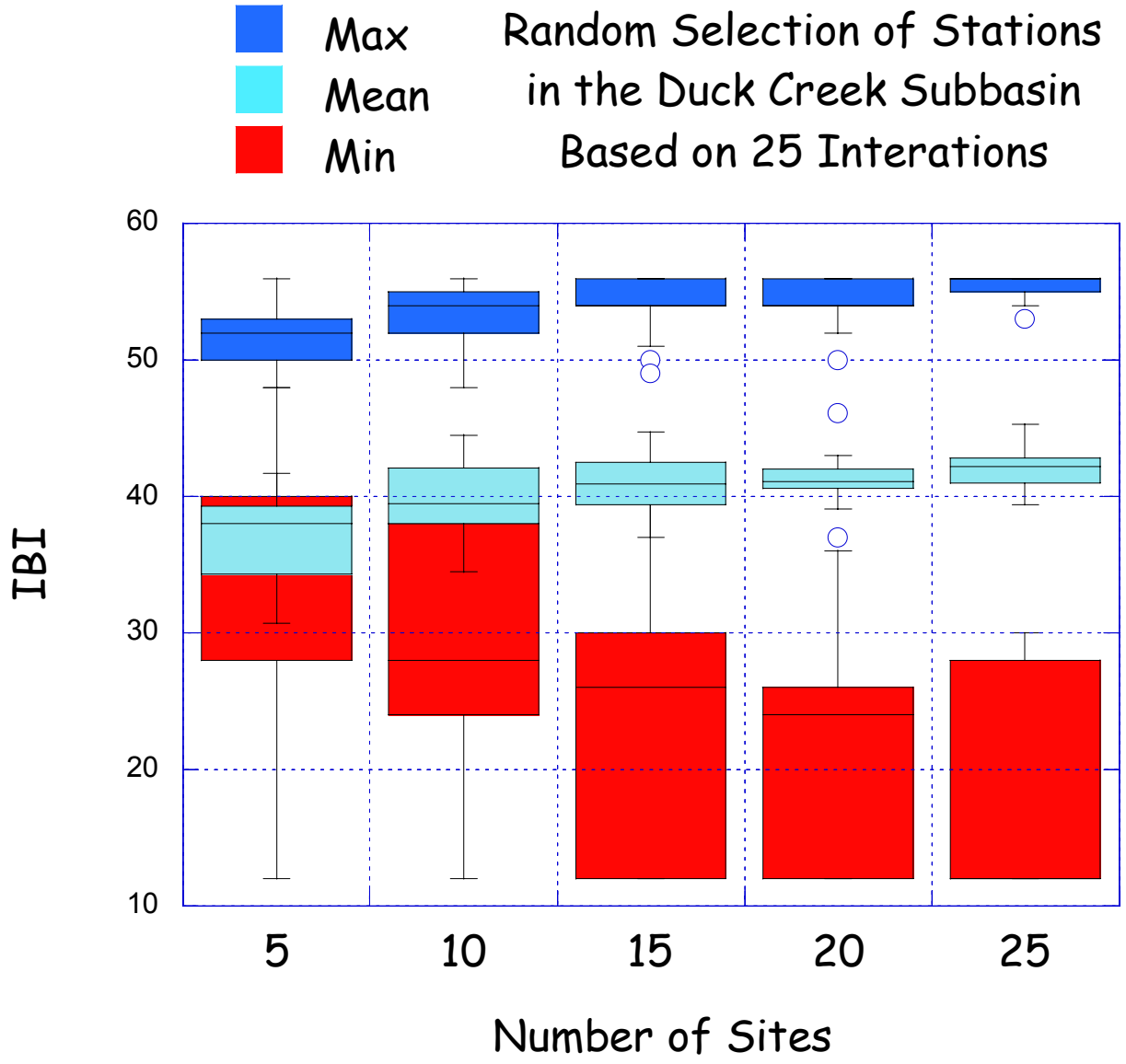
Sugar Creek Subbasin: Results of Geometric Design Assessment

- TMDL development scale: 11 digit HUC units, 328 statewide
- Mainstem rivers <500 mi^2 treated separately
- Watershed assessment results initially support UAA process
- Degree and severity of impairment then determined with biocriteria
- Causal associations determined via integrated analysis process
- **Supports prioritization ranking**
- More focused targeting of restoration activities
- **Local stakeholder "buy in" enhanced by scale of design**

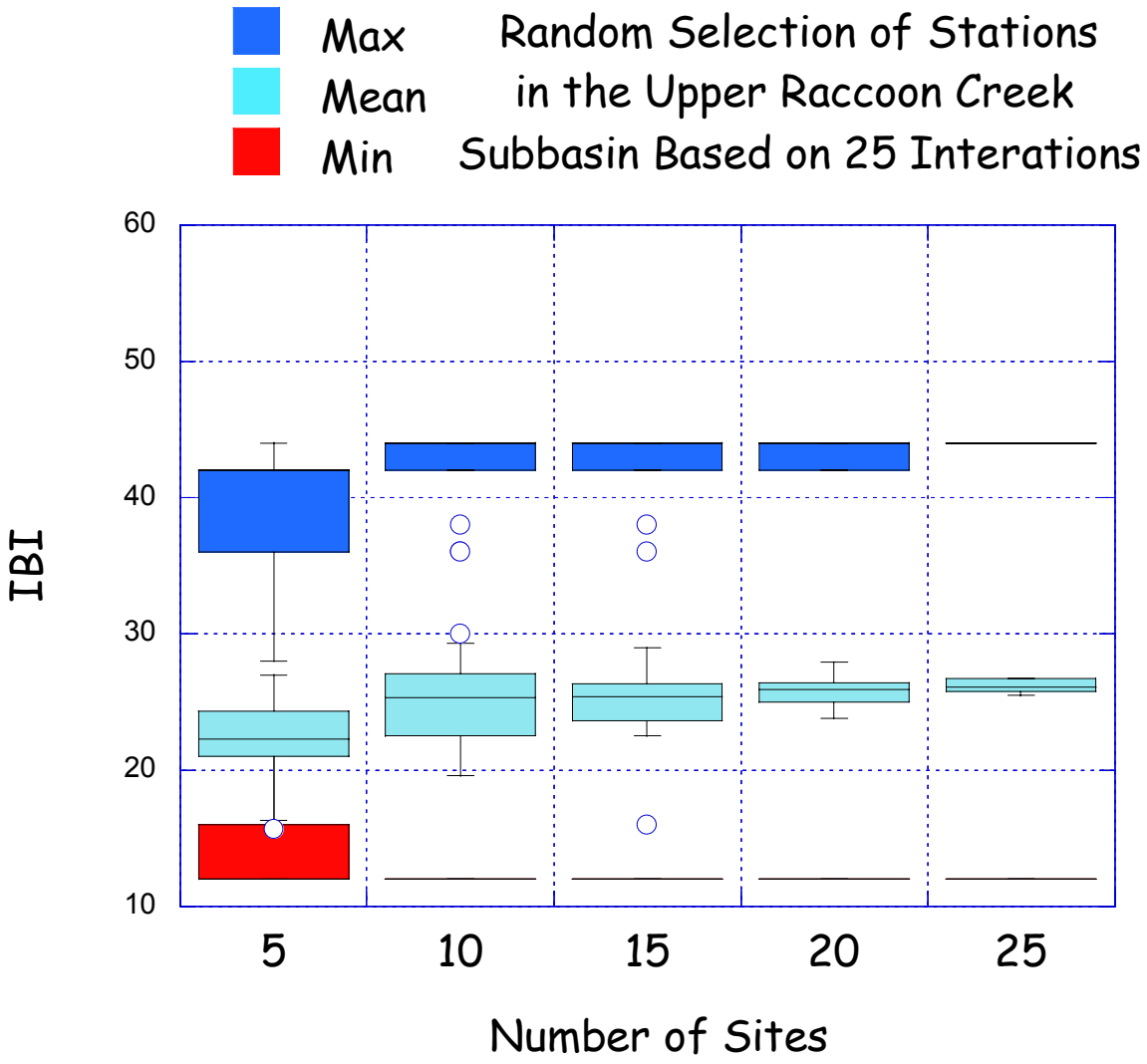
Initial Data Exploration

- Recombined data, without replacement, for 25 iterations to estimate mean IBI score in watershed.
- Selected scenarios using 5, 10, up to 25 stations per watershed.
- Results illustrated with box and whisker plot for three different watersheds sampled with the geometric design

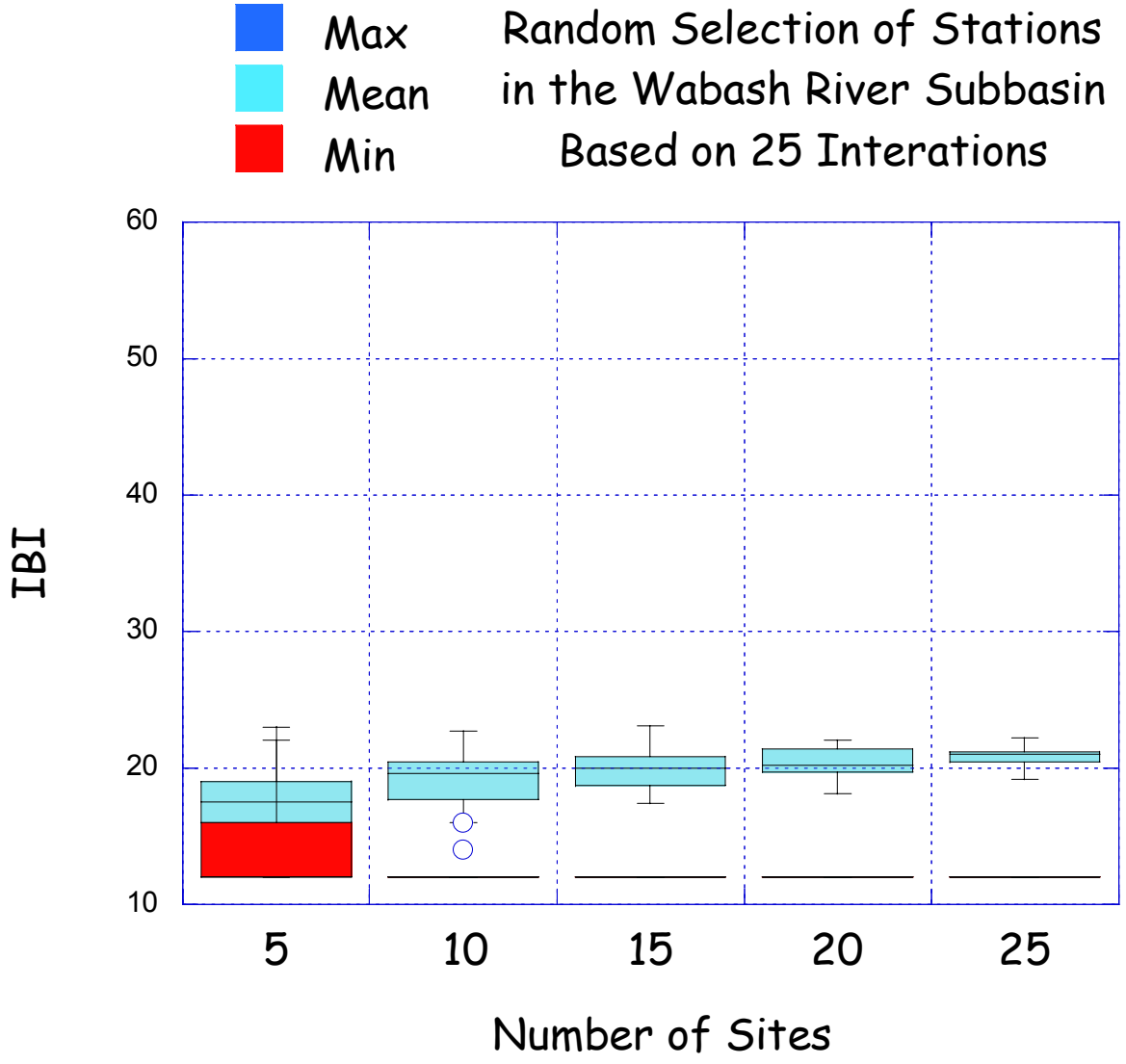
Duck Creek


Max
Mean
Min
Random Selection of Stations
in the Duck Creek Subbasin
Based on 25 Interations
IBI
60
50
40
30
20
10
5
10
15
20
25
Number of Sites

Raccoon Creek



Wabash River Watershed



Causes of Impairment

- How does the number of stations affect the assessment of causes of impairment in a watershed?
- Examples from previous watersheds:

Conclusions

- Indicators
  - Tiered Aquatic Life Uses resulted in more protection for high quality waters; did not over-protect more limited waters – this could have strong affect on TMDL lists
  - Multiple organism groups detected more impaired waters, largely though better identification of physically modified reaches

Conclusions, cont'd

- Water chemistry changes responsible for improvements in biota in Ohio waters
- Biological data better able to detect physical stressors not measured by water chemistry
- Some agreement between biology and water chemistry could also be coincidental
- Only a small proportion of sites show "independent application" conflict and most of these explainable

Monitoring Design

- Number of stations needed for an accurate estimate of watershed condition can vary with:
  - Actual variability in environmental conditions
  - Precision of monitoring tools
  - Needs for watershed management (e.g., identification of status vs. identification of causes (e.g., TMDLs, etc.)